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## **SUBSTRATE-BONDING DEVICE**

### **[Abstract]**

**PROBLEM TO BE SOLVED: To highly accurately and quickly bond a substrate in**

20 **vacuum.**

**SOLUTION: A first table 4 for detachably holding one of the upper and the lower substrates, and a second table 3 opposed to the first table 4 and to detachably hold the other substrate are provided in a vacuum chamber 2. A first moving means, which holds at least either of the tables 3 and 4 through first shafts 15**

25 **inserted into a plurality of first opening parts 2b of the vacuum chamber 2,**

respectively, and moves either in parallel with the glued surface of each substrate, and a second moving means which holds at least either of the tables 3 and 4, and moves vertically to the glued surface of each substrate are provided outside the vacuum chamber 2. Each first opening part 2b is provided with a first elastic 5 sealing member S1, which airtightly holds the space between the inside of the vacuum chamber 2 and the first shaft 15.

**[Claim(s)]**

**[Claim 1] A substrate bonding device carried out in such a manner that two substrates are disposed in a vacuum chamber, facing each other, one of the two substrates having an adhesive applied thereon, and the two substrates are**

5 **bonded to each other in a vacuumed state after position arrangement, having a predetermined extreme interval therebetween, the substrate bonding device comprising: a first table formed in the vacuum chamber for detachably supporting any of the two substrates; a second table formed in the vacuum chamber to face the first table, for detachably supporting the other substrate; a**

10 **first moving unit formed outside the vacuum chamber for supporting at least one of the first and second tables, placing first shafts inserted into a plurality of first opening portions formed at predetermined intervals on the bottom surface of the vacuum chamber between the first moving unit and at least one of the first and second tables, and for moving in a parallel direction with respect to the bonding**

15 **surfaces of the two substrates to conduct the position arrangement of the two substrates; a second moving unit formed outside the vacuum chamber for**

supporting at least one of the two substrates and moving in a vertical direction with respect to the bonding surfaces of the two substrates to conduct the bonding of the two substrates; and a first elastic seal member formed along the outer periphery of each of the first opening portions of the vacuum chamber for 5 maintaining air tightness between the vacuum chamber and each of the first shafts.

[Claim 2] A substrate bonding device as claimed in claim 1, wherein the first elastic seal member has an elastic bellows placed around the outer periphery of each of the first shafts in such a manner as to slide along the outer periphery of 10 each of the first shafts, having one end fixed to the outer periphery of each of the first opening portions of the vacuum chamber and the other end fixed to a magnetic seal.

[Claim 3] A device according to claim 2, wherein the elastic bellows is connected to the vacuum chamber at one end thereof, placing a slide member moving in a 15 parallel direction with respect to the bonding surfaces of the two substrates between the upper and lower ends thereof.

**[Claim 4] A device according to any one of claims 1, 2, or 3, wherein the second moving unit is formed to support at least one of the first and second tables in such a manner as to be connected to at least one of the first and second tables, placing second shafts inserted to a plurality of second opening portions formed**

5 **at predetermined intervals on the top surface of the vacuum chamber between at least one of the first and second tables and the second moving unit, and a second elastic seal member is formed along the outer periphery of each of the second opening portions of the vacuum chamber for maintaining air tightness between the vacuum chamber and each of the second shafts.**

**[Title of the Invention]**

**SUBSTRATE-BONDING DEVICE**

**[Detailed Description of the Invention]**

**[0001]**

5   **[Field of the Invention]** The present invention relates to a substrate bonding device, and more particularly, to a substrate bonding device that is allowed to bond upper and lower substrates facing each other in a vacuum chamber to each other, which is especially useful in assembling a liquid crystal display panel.

**[0002]**

10   **[Description of the Prior Art]** A liquid crystal display panel is constructed in such a manner that two glass substrates on which transparent electrodes or thin film transistor arrays are mounted are bonded at an extremely narrow interval of about several  $\mu$  m to each other as the one substrate is provided with a generally  $\square$ -shaped seal material that is formed on the peripheral surface thereof and is bonded to the other by means of adhesive applied on predetermined positions of the outer peripheries of the substrates (Hereinafter, the substrates

after bonding are referred to cells). Then, liquid crystal is filled in the space formed between the two substrates bonded by means of the adhesive.

[0003] A conventional substrate bonding device that carries out the filling of the liquid crystal in such a manner that the liquid crystal is first placed on the one 5 substrate on which the seal material is patterned in the □-shape, without having any liquid crystal inlet, and then, the other side substrate is placed over the one side substrate in a vacuum chamber, thereby bonding the two substrates to each other at a predetermined interval. This is disclosed in Japanese Patent Laid-Open Publication No. 2000-284295.

10 [0004] As disclosed in Japanese Patent Laid-Open Publication No. 2000-284295, the conventional device has a vacuum chamber that is divided into upper and lower chamber units. The one side substrate is placed on the back surface of a pressurizing plate in the upper chamber unit, and the other side is placed on the table in the lower chamber unit. And, the conventional device couples the upper 15 and lower chamber units with each other to thereby form the single vacuum chamber in which the two substrates face each other.

[0005] At this time, in the conventional device the upper and lower chamber units are moved along the table in the parallel direction to the bonding face of each substrate, thus to execute position arrangement of the two substrates. Next, the interval between the two substrates becomes little by little narrow such that the 5 upper and lower substrates are bonded to each other, being placed between the pressurizing plate and the table.

[0006] Furthermore, the table of the device is a part of the lower chamber unit in such a manner as to be moved horizontally freely together with the lower chamber unit in a state of being separated from the upper chamber unit. Thereby, 10 the table is used as a part of the returning system of the lower substrate, which is effectively utilized upon coating the seal material, the adhesive, and the liquid crystal.

[0007]

[Problem(s) to be Solved by the Invention] According to the prior art, since the 15 position arrangement of the two substrates are conducted in the vacuumed state, the coupled portion of the upper and lower chamber units and the assembled

portion of the lower chamber unit with the table have the pressure applied by the atmospheric pressure which is in proportion to their area in the vacuum chamber.

For example, if the vacuum chamber having a diameter of 700 mm is used to

bond the glass substrates each having a size 400 mm x 500 mm, the coupling

5 portion of the upper and lower chamber units has the load of 38.9 kN (3.97 X 103 kgf) applied thereto.

[0008] Moreover, as the size of substrate becomes large, recently, the load

applied to the coupling portion or the assembled portion becomes increased, such that it is difficult to move the table with precision upon position

10 arrangement of the two substrates.

[0009] To remove the above-discussed problems, at this time, there is a way of

reducing the area of the assembled portion of the table with the lower chamber unit, not to apply the load thereto. In this case, the support member of the table

has to be reduced in thickness, but since it is used to support the center portion

15 of the table, the reduction of thickness of the support member causes the periphery of the table to be undesirably bent. Thus, the lower substrate is bent

upwardly with respect to the upper substrate, which fails to obtain good bonding results between the upper and lower substrates.

[0010] To maintain the lower substrate at a flat state, there is a way of raising the stiffness of the table. In this case, however, the table gets heavy. If the heavy

5 table is supported by a relatively thin support member, it is easily to be shaken.

Therefore, the table should be moved with carefulness upon the position arrangement of each substrate. Thus, the formation of heavy table causes the working efficiency to be considerably low. This way also fails to obtain good bonding results between the upper and lower substrates.

10 [0011] Accordingly, the present invention has been made in view of the above-mentioned problems occurring in the prior art, and an object of the present invention is to provide a substrate bonding device that can execute the bonding of substrates in a vacuumed state with precision and at a substantially high speed.

15 [0012]

[Means for Solving the Problem] To achieve the above object, according to the present invention as claimed in claim 1, a substrate bonding device is carried out

in such a manner that two substrates are disposed in a vacuum chamber, facing

each other, one of the two substrates having adhesive applied thereon, and the

5 two substrates are bonded to each other in a vacuumed state after position

arrangement, having a predetermined extreme interval therebetween, the

substrate bonding device including: a first table formed in the vacuum chamber

for detachably supporting any of the two substrates; a second table formed in the

vacuum chamber to face the first table, for detachably supporting the other

10 substrate; a first moving unit formed outside the vacuum chamber for supporting

at least one of the first and second tables, placing first shafts inserted into a

plurality of first opening portions formed at predetermined intervals on the

bottom surface of the vacuum chamber between the first moving unit and at least

one of the first and second tables, and for moving in a parallel direction with

15 respect to the bonding surfaces of the two substrates to conduct the position

arrangement of the two substrates; a second moving unit formed outside the

vacuum chamber for supporting at least one of the two substrates and moving in a vertical direction with respect to the bonding surfaces of the two substrates to conduct the bonding of the two substrates; and a first elastic seal member formed along the outer periphery of each of the first opening portions of the

5 vacuum chamber for maintaining the air tightness between the vacuum chamber and each of the first shafts.

[0013] According to the present invention as claimed in claim 1, the first elastic seal member has an elastic bellows placed around the outer periphery of each of the first shafts in such a manner as to slide along the outer periphery of each of the first shafts, having one end fixed to the outer periphery of each of the first opening portions of the vacuum chamber and the other end fixed to a magnetic seal.

[0014] According to the present invention as claimed in claim 2, the elastic bellows is connected to the vacuum chamber at one end thereof, placing a slide member moving in a parallel direction with respect to the bonding surfaces of the two substrates between the upper and lower ends thereof.

[0015] According to the present invention as claimed in any of claim 1, 2, or 3, the second moving unit is formed to support at least one of the first and second tables in such a manner as to be connected to at least one of the first and second tables, placing second shafts inserted to a plurality of second opening portions 5 formed at predetermined intervals on the top surface of the vacuum chamber between at least one of the first and second tables and the second moving unit, and a second elastic seal member is formed along the outer periphery of each of the second opening portions of the vacuum chamber for maintaining the air tightness between the vacuum chamber and each of the second shafts.

10 [0016]

[Embodiment of the Invention] Hereinafter, an explanation of the substrate bonding device according to the preferred embodiment of the present invention is given with reference to FIGS. 1 to 5.

[0017] In FIG. 1, a reference numeral 1 denotes the substrate bonding device of 15 the present invention. The substrate bonding device 1, as shown in FIG. 1, includes a vacuum chamber 2 in which two substrates (hereinafter, the one

substrate is referred to as the upper substrate B1, and the other as the lower substrate B2) are bonded in a vacuumed sate, an upper table 3 (a second table) supporting the upper substrate B1, a lower table (a first table) 4 supporting the lower substrate B2, a Z-axis movement base 10 for moving the upper table 3 in 5 upward and downward directions (in a direction of axis Z in FIG. 1), a movement table T1 (first moving unit) for moving the lower table 4 in a horizontal direction, that is, in forward and backward directions (in a direction of axis Y in FIG. 1), in left and right directions (in a direction of axis X in FIG. 1), and in a direction of axis θ in FIG. 1, and a mark observation optical system C1 for observing the 10 position arrangement marks of the upper and lower substrates B1 and B2.

[0018] First, an explanation of the construction of the vacuum chamber 2 is given. The vacuum chamber 2 is provided with an opening portion 2c to and from which the upper and lower substrates B1 and B2 are inserted and drawn, a gate valve 5 for opening/closing the opening portion 2c in such a manner as to move the 15 opening portion 2c in upward and downward directions, and an exhaust valve 6

connected to a vacuum pump which is not shown for exhausting air to make the vacuum chamber 2 in a vacuumed state.

[0019] Further, the vacuum chamber 2 is provided with a plurality of support

cleats 7 supporting the upper and lower substrates B1 and B2 and a support

5 mechanism 8 moving the plurality of support cleats 7 in the upward and

downward directions and in the forward and backward directions. At this time, a

pair of support mechanism 8 are mounted at the both ends of the upper and lower

substrates B1 and B2 inserted from the opening portion 2c of the vacuum

chamber 2(at the both end portions thereof in the forward and backward

10 directions with respect to the plurality of support cleats 7 in such a manner as to

support the upper and lower substrates B1 and B2 horizontally (in a parallel

relation to the planes X and Y in FIG. 1).

[0020] The vacuum chamber 2 is further provided on the upper portion thereof

with a plurality of windows 27 through which the position arrangement marks of

15 the upper and lower substrates B1 and B2 are observed through through holes

(which are not shown) formed on the upper table 3 by means of the mark observation optical system C1.

[0021] Next, an explanation of the construction of the upper table 3 and the Z-axis

movement base 3 is given. The upper table 3 has static suction electrodes and

5 vacuum suction holes thereon to protect and support the upper substrate B1

from the static electricity and vacuum suction. Under the above construction, the

upper table 3 is connected to the Z-axis movement base 10 through a second

shaft 9 that is inserted and connected to each of four opening portions (second

opening portions) 2a formed on the vacuum chamber 2.

10 [0022] At this time, the Z-axis movement base 10 is moved in the upward and

downward directions by having a pair of liner guides 11A formed at the both ends

thereof, a pair of guide members 11A mounted to the frame of a device

cooperating with the linear guides 11A in such a manner as to be moved in

upward and downward directions, a motor 12 having the same output shaft as the

15 axis Z of FIG. 1, and a ball screw 13 having one end cooperating with the Z-axis

movement base 10 and the other end cooperating with the output shaft of the

motor 12. Thereby, the upper table 3 is ascendable and descendable in the upward and downward directions.

[0023] Between the outer periphery of each of the opening portions 2a and the Z-

axis movement base 10 is provided a vacuum seal (a second elastic seal member)

5 that is mounted on the outer periphery of each of the second shafts 9, such that

when the second shafts 9 each are moved upwardly and downwardly together

with the Z-axis movement base 10, the vacuum chamber 2 is kept at the air sealed

state. As shown in FIG. 1, the vacuum seal is formed of a vacuum bellows (an

elastic bellows) that is mounted over the vacuum chamber 2, secured on the

10 periphery of each of the opening portions 2a at one end thereof and on the Z-axis

movement base 10 at the other end thereof, such that the vacuum chamber 2

maintains the air sealed state after the vacuuming process to allow the upper

table 3 to be ascendably and descendably moved.

[0024] Next, an explanation on the construction of the lower table 4 and the

15 movement table T1 will be given hereinafter. The lower table 4 has static suction

electrodes and vacuum suction holes thereon to protect and support the lower

substrate B2 from the static electricity and vacuum suction. Under the above construction, the lower table 4 is connected to the movement table T1 through a first shaft 15 that is inserted and connected to each of four opening portions (first opening portions) 2b formed on the vacuum chamber 2.

- 5 [0025] The movement table T1 has an X stage 16 formed at the lower portion of the device, a Y stage 18 disposed on the X stage 16, a  $\theta$  stage 20 disposed on the Y stage, and a plate-like assembling body 15A mounted on the  $\theta$  stage 20 in such a manner as to be fixed on the lower ends of the first shafts 15. At this time, the X stage 16 is configured such that the Y stage 18 is moved in the left and right directions (the direction of axis X) by means of a driving motor 17, and the Y stage 18 is configured such that the  $\theta$  stage 20 is moved in the forward and downward directions (the direction of axis Y) by means of a driving motor 19. Moreover, the  $\theta$  stage 20 is configured such that the assembling body 15A is moved in the direction of axis  $\theta$  of FIG. 1 by means of a driving motor 22, placing 15 a rotary bearing 21 between the assembling body 15A and the  $\theta$  stage 20.

[0026] In this case, between the outer periphery of each of the opening portions 2b and the movement table T1 is provided a vacuum seal (a first elastic seal member) S1 that is mounted on the outer periphery of each of the first shafts 15, such that when the first shafts 15 each are moved upwardly and downwardly 5 together with the movement table T1, the vacuum chamber 2 is kept at the air sealed state. As shown in FIG. 1, the vacuum seal S1 includes a vacuum bellows (an elastic bellows) 23 that is fixed to the vacuum chamber 2 at the bottom end portion thereof, a magnetic seal 24 disposed on the lower portion of the vacuum bellows 23, a cross roller guide (slide member) 25 mounted at the lower portion of 10 the magnetic seal 24, and a support base 26 disposed downwardly of the lower portion of the cross roller guide 25.

[0027] In this case, the magnetic seal 24 includes bearings 24a and 24b adapted to slide along the outer periphery of each of the first shafts 15, a magnetic body seal member 24c mounted between the bearings 24a and 24b, and a housing 24d 15 accommodating the bearings 24a and 24b and the magnetic body seal member 24c therein.

**[0028]** As shown in FIGS. 1 and 5, the cross roller guide 25 is provided with an upper plate 25a fixed at the bottom of the housing 24d, '#'-shaped four guide shafts 25b, and four maintaining bodies 25c formed at the cross portions with the guide shafts 25b in such a manner as to slide along the guide shafts 25b. As

5 shown in FIG. 5, at this time, the guide shafts 25b are formed of the two X-direction guide shafts each are extended to the direction of axis X and fixed at the bottom surface of the upper plate 25a and the two Y-direction guide shafts each are extended to the direction of axis Y and fixed to a support plate of the support base 26 as will be discussed below. Also, the maintaining bodies 25c each have

10 a groove portion through which the X-direction guide shaft freely slides at the one surface thereof (the top surface thereof in FIG. 1) and a groove portion through which the Y-direction guide shaft freely slides at the other surface thereof (the bottom surface thereof in FIG. 1).

**[0029]** The support base 26 has support members formed downwardly of the

15 lower portion of the vacuum chamber 2 and the support plate fixed at the bottom portions of the support members.

[0030] At this time, the vacuum bellows 23 is fixed to the periphery of each of the opening portions 2b of the vacuum chamber 2 at the top end thereof and fixed to the top end portion of the housing 24d at the bottom end thereof. Also, the housing 24d is fixed to the upper plate 25a of the cross roller guide 25 at the 5 bottom end portion thereof. Moreover, the cross roller guide 25 is fixed to the support plate of the support base 26 secured to the vacuum chamber 2 at the bottom portion thereof.

[0031] At this time, each of the first shafts 15 is inserted and connected into a passage (having a larger outer diameter than the first shaft 15) formed on the 10 upper plate 25a of the cross roller guide 25 and the support base 26, which is not shown in the drawing. In this case, if the first shaft 15 is moved together with the movement table T1, since the vacuum bellows 23 is coupled to the cross roller guide 25 at the lower end thereof, placing the magnetic seal 24 therebetween, it is moved horizontally together with the cross roller guide 25. Additionally, if the 15 movement table T1 is rotated in the direction of axis  $\theta$  as shown in FIG. 1, the

magnetic body seal member 24c of the magnetic seal 24 serves to suck the rotating force of the first shaft 15.

[0032] Then, an explanation of the construction of the mark observation optical system C1 is given. The mark observation optical system C1 includes an image recognizing camera 28 and an XYZ stage 29 that moves the image recognizing camera 28 in the directions of axes X, Y, and Z, as shown in FIG. 1. At this time, 5 the XYZ stage 29 has an electric motor having the output shafts in the directions of axes X, Y, and Z such that the image recognizing camera 28 can be moved to each axis direction. The mark observation optical system C1 is mounted 10 upwardly of each of the windows 27 of the vacuum chamber 2 such that it can observe the position arrangement marks formed on the two crossed portions or the four portions of the upper and lower substrates B1 and B2.

[0033] Now, an explanation of the operations of the substrate bonding device 1 of the present invention is given with reference to FIGS. 1 and 5.

15 [0034] At this time, seal is coated to predetermined height and section (width) in a generally □-shaped line on any (the lower substrate B2 in the preferred

embodiment of the present invention) of the upper and lower substrates B1 and B2 such that when the upper and lower substrates B1 and B2 are bonded to each other, liquid crystal is poured in the portion into which the seal is formed. Also, the upper substrate B1 supported by the upper table 3 is previously placed 5 toward the lower portion (the lower portion of FIGS. 2 to 4). Furthermore, a predetermined amount of liquid crystal is filled on the lower substrate B2 supported by the lower table 4 such that the interval between the upper and lower substrates B1 and B2 is an optimal gap when the upper and lower substrates B1 and B2 are bonded.

10 [0035] First, the lower substrate B2 on which the seal is coated and patterned and the liquid crystal is filled in the inside of the □-shaped seal pattern is sucked and fixed on the hand 30 of a substrate conveying robot, as shown in FIG. 2. Then, the gate valve 5 of the vacuum chamber 2 is opened to cause the opening portion 2c of the vacuum chamber 2 to be opened. After that, the hand 30 of the 15 substrate conveying robot is inserted into the opening portion 2c to release the suction of the lower substrate B2.

[0036] Before the suction of the lower substrate B2 is released, at this time, the support mechanism 8 moves the support cleats 7 toward the lower substrate B2 (in the direction of axis Y in FIG. 2) and also raises it in the direction of axis Z in FIG. 2, with a result of contacting the support cleats 7 with the bottom surface of

5 the lower substrate B2. After the support cleats 7 are contacted with the bottom surface of the lower substrate B2, the suction of the lower substrate B2 is released to allow the lower substrate B2 to be supported by means of the support cleats 7, thereby transferring the lower substrate B2.

[0037] After the transferring of the lower substrate B1 is finished, the substrate

10 conveying robot retracts the hand 30, and after the retracting, the support mechanism 8 is descended to transfer the lower substrate B2 on the lower table 4, such that the lower substrate B2 is supported by the lower table 4. At this time, the lower table 4 has grooves (which are not shown) into which the support cleats 7 are inserted, and as the support mechanism 8 is descended, the support cleats

15 7 are inserted into the grooves of the lower table 4. Also, the support cleats 7 are moved downwardly from the surface (the supported surface of the lower

substrate B2) of the lower table 4, with a result that the lower substrate B2 is transferred on the lower table 4, as shown in FIG. 3.

[0038] After the lower substrate B2 is vacuumed and sucked on the lower table 4,

the support mechanism 8 retracts and raises the support cleats 7 from the lower

5 substrate B2, and then moves the support cleats 7 again to transfer the upper substrate B1.

[0039] After that, the upper substrate B1 is sucked and fixed on the hand 30 of the

substrate conveying robot, as discussed above, and the hand 30 of the substrate

conveying robot is inserted into the opening portion 2c. After that, the suction of

10 the suction of the upper substrate B1 is released to cause the support mechanism 8 to raise the support cleats 7 such that the upper substrate B1 is transferred on the support cleats 7.

[0040] After the transferring of the upper substrate B2 is finished, the support

mechanism 8 ascends the upper substrate B1 such that the upper substrate B1 is

15 supported by the upper table 3. After the upper substrate B1 is vacuumed and sucked on the upper table 3, the support cleats 7 still remain at the positions.

And, the substrate conveying robot retracts the hand 30, and if the retracting is finished, the gate valve 5 is closed to allow the opening portion 2c to be closed. After that, the vacuum chamber 2 is vacuumed by using the vacuum pump connected to the exhaust valve 6.

5 [0041] At a point where the vacuum pressure of the vacuum chamber 2 reaches a predetermined desired pressure by the vacuum exhaustion, the support force of the upper table 3 with respect to the upper substrate B1 is converted to the static suction by using a static zipper (static electrodes). At this time, the support mechanism 8 retracts the support cleats 7 after the upper substrate B1 is 10 supported on the upper table 3 in the static suction state.

[0042] Further, when the support cleats 7 are raised, the upper table B1 is not vacuumed and sucked on the upper table 3 but supported by means of the support cleats 7. At the point where the vacuum pressure of the vacuum chamber 2 reaches the predetermined desired pressure by the vacuum exhaustion, the upper table 3 just supports the upper substrate B1 in the static 15 suction state.

[0043] Next, if the support cleats 6 are retracted, the motor 12 is driven to descend the Z-axis movement base 10, as shown in FIG. 4 and thus to move the upper substrate B1 near to the lower substrate B2. And, in the state where the upper and lower substrates B1 and B2 are adjacent to each other, the position arrangement marks are photographed by the image recognizing camera 28 of the mark observation optical system C1, and the XYZ stage 29 is controlled to correspond the center axis of the image recognizing camera 28 with the position arrangement marks.

[0044] After that, the deviation percentage between the position arrangement marks on the upper substrate B1 and those on the lower substrate B2 is obtained. Then, based upon the deviation percentage, the movement table T1 is driven to correspond the position arrangement marks on the upper substrate B1 with those on the lower substrate B2. Hereinafter, an explanation of the movement of the first shafts 15, the magnetic seal 24 and the cross-roller guide 25 in the position arrangement of the upper and lower substrates B1 and B2 by the movement table T1 is given with reference to FIG. 5.

[0045] A symbol P in FIG. 5 denotes the center position of the support base 26, and Q denotes the center position of the assembling body 15A. Unlike FIG. 1, on the other hand, the assembling body 15A in FIG. 5 is formed larger than the support base 26 so as to easily understand the construction of FIG. 5. Also, the 5 position arrangement is explained with respect to the first shaft 15 placed at the upper portion of the left side of the figure.

[0046] As shown in FIG. 5, as the Y-axis direction guide shafts of the cross roller guide 25 are fixed to the support base 26, they do not move, but the X-axis direction guide shafts thereof move by means of the movement of the first shafts 10 15 fixed to the assembling body 15A, placing the magnetic seal 24 and the upper plate 25a of the cross roller guide 25 therebetween. At this time, the lower end of the vacuum bellows 23 is fixed to the housing 24d of the magnetic seal 24 fixed to the upper plate 25a and does not rotate itself, thereby carrying out the movement in the horizontal direction (the direction of axes X and Y). Further, since the first 15 shafts 15 are fixed to the assembling body 15A, they are all rotated in the

direction of axis  $\theta$  . The displacement of rotation between each of the first shaft 15 and the vacuum bellows 23 is absorbed by means of the magnetic seal 24.

[0047] When the position arrangement of the upper and lower substrates B1 and

B2 is carried out, therefore, the lower table 4 is moved in the direction of each of

5 the axis X, Y, and  $\theta$  as shown in FIG. 5 by using the movement table T1, placing

the assembling body 15A and each of the first shafts 15 between the lower table 4

and the movement table T1, and at this time, the movement of each first shaft 15

is absorbed by the magnetic seal 24 to the cross roller guide 25, such that the

vacuum chamber 2 can be maintained at a vacuumed state, without any damage

10 of the vacuum bellows 23.

[0048] The range of movement of the movement table T1 for the position

arrangement of the upper and lower substrates B1 and B2 is just from the

assembling body 15A of each of the first shafts 15 to the lower table 4. At this

time, as the lower table 4 is supported by the plurality of first shafts 15, there is

15 no need to make the strength raised. Also, as the plurality of first shafts 15 are

used to support the lower table 4, each of them may have a substantially low

thickness. Also, each of the magnetic seals 24 may become small-sized. The lower table 4, the first shafts 25, and the magnetic seals 24 are moved by the movement table T1 can have relatively light weight. In this case, when the vacuum chamber 2 is vacuumed, the external pressure applied to the magnetic seals 24 can be reduced.

5 [0049] According to the substrate bonding device of the present invention, the lower table 4 can maintain the flatness to allow the upper and lower substrates B1 and B2 to be kept in a parallel relation to each other, thereby obtaining the lightness of the weight and the reduction of the external pressure. Thus, the 10 position arrangement can be conducted with ease and precision and at a very high speed by using the image recognizing camera 28.

[0050] Furthermore, in the construction of the present invention, the external pressure applied to the magnetic seals 24 works in the direction (the upward and downward directions in FIG. 1) of compressing the vacuum bellows 23, but in the 15 preferred embodiment of the present invention, it is transferred to the support base 26, placing the cross roller guides 25 between the magnetic seals 24 and the

support base 26. Thus, the load of the vacuum bellows 23 itself becomes low so that the lifetime of the fixed portions formed by welding is not reduced.

[0051] After the position arrangement of the upper and lower substrates B1 and

B2 is carried out in the manner as mentioned above, next, the upper table 3 is

5 further descended by using the Z-axis movement base 10 such that the upper and lower substrates B1 and B2 are bonded to each other, having a predetermined amount of seal applied between them.

[0052] At this time, the upper and lower substrates B1 and B2 are maintained in

the parallel relation to each other, and even if the seal is removed, there is no

10 problem that it still remains therebetween. Also, the interval between the upper and lower substrates B1 and B2 becomes narrow at a constant speed, such that

the liquid crystal is pressed and little by little spreads in the inside of the □-shaped area formed by the seal. At this state, the position arrangement of the

upper and lower substrates B1 and B2 is not misaligned, and light is irradiated by

15 using light source to light hardening adhesive previously coated for temporarily fixing the substrates B1 and B2 thus to prevent the position to be arranged from

differing from the real position. Then, the upper and lower substrates B1 and B2 are temporarily fixed.

[0053] After that, the static suction between the upper and lower substrates B1 and B2 is released to raise the upper table 3, and the exhaust valve 6 is closed.

5 Next, the vacuum chamber 2 is in an atmospheric pressure by opening an atmospheric opening valve which is not shown in the drawing. Thereby, as the atmospheric pressure works between the upper and lower substrates B1 and B2, the upper and lower substrates B1 and B2 are pressurized to allow the liquid crystal to spread in the whole area formed by the seal.

10 [0054] After the vacuum chamber 2 has been under the atmospheric pressure, the support mechanism 8 descends the support cleats 7 to the grooves on the lower table 4. Then, the support mechanism 8 permits the support cleats 7 to be moved forwardly and ascended, such that the upper and lower substrates B1 and B2 at the temporarily fixed state are supported and transferred by the support cleats 7.

15 [0055] Next, the gate valve 5 is opened to allow the opening portion 2c of the vacuum chamber 2 to be opened such that the hand 30 of the substrate

conveying robot is inserted through the opening portion 2c. By using the hand 30, the upper and lower substrates (the cells) B1 and B2 that are bonded to each other and supported on the support cleats 7 are drawn and delivered to a device of conducting next real processes. At this time, the real bonding may be finished 5 in the vacuum chamber 2.

[0056] In the preferred embodiment of the present invention, the four first shafts 15 are employed to support the lower table 4, but the number of first shafts is not limited thereto and is adjustable appropriately. Also, the number of first shafts 15 may be set differently from that of second shafts 9.

10 [0057] In the preferred embodiment of the present invention, so as to align and bond the upper and lower substrates B1 and B2, the movement of the direction of axis Z between the upper and lower substrates B1 and B2 is conducted by the upper table 3 side, but as discussed above, the weight of the movement table T1 can be light, such that it is possible to have the movement table T1 (which is 15 mounted at the same position as the upper table 3 and conducts the same

operation as the upper table 3) on which a Z-axis table is mounted employed in the present invention.

[0058] Additionally, the substrate bonding device of the present invention is not restricted to the manufacturing process of a liquid crystal display, but for example, it is applicable to the bonding process of a register film on the substrate in the vacuum chamber and to a bonding process of a print substrate in the vacuum chamber.

[0059]

[Effects of the Invention] As set forth in the foregoing, according to the present invention, a substrate bonding device can execute the bonding of substrates in a vacuumed state with precision and at a substantially high speed.

[Description of Drawings]

FIG. 1 is a side view showing the construction of a substrate bonding device according to the present invention.

15 FIG. 2 is a view describing the operation of inserting a lower substrate in a vacuum chamber in the substrate bonding device of the present invention.

FIG. 3 is a view describing the operation of moving and transferring the lower substrate on a lower table in the substrate bonding device of the present invention.

FIG. 4 is a view describing the operation of the position arrangement of the 5 upper and lower substrates and the bonding operation of the substrates in the substrate bonding device of the present invention.

FIG. 5 is a view describing the movements of first shafts, magnetic seals and cross roller guides upon operation of position arrangement of the upper and lower substrates, when viewed from the top of the drawing.

10 [Explanation on Reference Numerals]

1: substrate bonding device

2: vacuum chamber

3: upper table

4: lower table

15 5: gate valve

9: second shaft

**10: Z-axis movement table**

**12: motor**

**14 and 23: vacuum bellows**

**15: first shaft**

5      **24: magnetic seal**

**25: cross roller guide**

**T1: movement table**

**S1: vacuum seal**

**C1: mark observation optical system**

10      **B1: upper substrate**

**B2: lower substrate**